

CLAIMS

1. A surface acoustic wave filter comprising: a piezoelectric substrate; and a longitudinally-coupled-resonator surface acoustic wave filter portion provided on the piezoelectric substrate,

wherein:

the longitudinally-coupled-resonator surface acoustic wave filter portion comprises: an odd number of at least three interdigital transducers formed so that a plurality of comb electrodes having a plurality of electrode fingers are combined to oppose, the interdigital transducers being disposed along a surface-acoustic-wave propagation direction; and first and second reflectors disposed along the surface-acoustic-wave propagation direction so that the three interdigital transducers are positioned between both reflectors;

the odd number of at least three interdigital transducers comprises: a central interdigital transducer positioned in the center; and first and second interdigital transducers disposed at two sides of the central interdigital transducer, an electrode finger of the first interdigital transducer which is adjacent to the central interdigital transducer is a ground electrode, and an electrode finger of the second interdigital transducer which is adjacent to the central interdigital transducer is a signal electrode;

one side of the opposing comb electrodes of the central interdigital transducer comprises: first and second bisected comb electrodes obtained by bisection along the surface-acoustic-wave propagation direction;

the first and second bisected comb electrodes are respectively disposed closer to the first and second

interdigital transducers and are respectively connected to first and second balanced signal terminals;

the first and second interdigital transducers which are adjacent to the central interdigital transducer are connected to an unbalanced signal terminal; and

when, in the central interdigital transducer, an imaginary central axis orthogonal to the surface-acoustic-wave propagation direction is assumed, design parameters of the interdigital transducers and/or the reflectors, which are disposed at two sides of the imaginary central axis, are set to differ at the sides of the imaginary central axis.

2. The surface acoustic wave filter according to Claim 1, wherein the interdigital transducers and/or the reflectors, which are disposed at two sides of the imaginary central axis, are asymmetrically formed at the sides of the imaginary central axis.

3. The surface acoustic wave filter according to Claim 1 or 2, wherein:

the polarities of two outermost electrode fingers of the central interdigital transducer are identical to that of the ground electrode or a float electrode; and

the electrode finger pitch of at least a part of the first interdigital transducer is greater than the electrode finger pitch of the second interdigital transducer.

4. The surface acoustic wave filter according to Claim 1 or 2, wherein both the polarities of two outermost electrode fingers of the central interdigital transducer are identical to that of the signal electrode, and the electrode finger pitch of at least a part of the second interdigital transducer is greater than the electrode finger pitch of the first interdigital transducer.

5. The surface acoustic wave filter according to one of Claims 1 to 4, wherein the electrode finger pitch of at least a part of the first bisected comb electrode between the first and second bisected comb electrodes, which is closer to the first interdigital transducer, is greater than the electrode finger pitch of the second bisected comb electrode.

6. The surface acoustic wave filter according to one of Claims 1 to 5, wherein an adjacent-electrode-finger center-to-center distance between the first interdigital transducer and the central interdigital transducer is greater than an adjacent-electrode-finger center-to-center distance between the second interdigital transducer and the central interdigital transducer.

7. The surface acoustic wave filter according to one of Claims 1 to 3, 5, and 6, wherein both the polarities of two outermost electrode fingers of the central interdigital transducer are identical to that of a ground electrode or a float electrode, and an electrode-finger center-to-center distance between the first interdigital transducer and the first reflector adjacent to the first interdigital transducer is greater than an electrode-finger center-to-center distance between the second interdigital transducer and the second reflector adjacent to the second interdigital transducer.

8. The surface acoustic wave filter according to one of Claims 1, and 4 to 6, wherein both the polarities of two outermost electrode fingers of the central interdigital transducer are identical to that of a signal electrode, and an electrode-finger center-to-center distance between the second interdigital transducer and the second reflector adjacent to the second interdigital transducer is greater than an electrode-finger center-to-center distance between the first interdigital

transducer and the first reflector adjacent to the first interdigital transducer.

9. The surface acoustic wave filter according to one of Claims 1 to 8, wherein the duty of electrode fingers in at least a part of the first interdigital transducer is greater than the duty of electrode fingers of the second interdigital transducer.

10. The surface acoustic wave filter according to one of Claims 1, 3 to 7, and 9, wherein both the polarities of two outermost electrode fingers of the central interdigital transducer are identical to that of a ground electrode or a float electrode, and the duty of electrode fingers of the first bisected comb electrode is greater than the duty of electrode fingers of the second bisected comb electrode.

11. The surface acoustic wave filter according to one of Claims 1, 4 to 6, 8, and 9, wherein both two outermost electrode fingers of the central interdigital transducer are signal electrodes, and the duty of electrode fingers of the second bisected comb electrode is greater than the duty of electrode fingers of the first bisected comb electrode.

12. The surface acoustic wave filter according to one of Claims 1 to 11, wherein:

the odd number of at least three interdigital transducers has, in areas in which two interdigital transducers are adjacent to each other, narrow pitch electrode finger portions having relatively smaller electrode finger pitches compared with surrounding electrode finger portions; and

the electrode finger pitch of one narrow pitch electrode finger portion in an area in which the first interdigital transducer and the first bisected comb electrode are adjacent to each other is greater than the electrode finger pitch of one

narrow pitch electrode finger portion in an area in which the second interdigital transducer and the second bisected comb electrode are adjacent to each other.

13. A surface acoustic wave filter comprising: a piezoelectric substrate; and a longitudinally-coupled-resonator surface acoustic wave filter portion disposed on the piezoelectric substrate,

wherein:

the longitudinally-coupled-resonator surface acoustic wave filter portion comprises: an odd number of at least three interdigital transducers formed so that a plurality of comb electrodes having a plurality of electrode fingers are combined to oppose, the interdigital transducers being disposed along a surface-acoustic-wave propagation direction; and first and second reflectors disposed along the surface-acoustic-wave propagation direction so that the three interdigital transducers are positioned between both reflectors;

the odd number of at least three interdigital transducers comprises: a central interdigital transducer positioned in the center; and first and second interdigital transducers disposed at two sides of the central interdigital transducer, an electrode finger of the first interdigital transducer which is adjacent to the central interdigital transducer is a ground electrode, and an electrode finger of the second interdigital transducer which is adjacent to the central interdigital transducer is a signal electrode;

one side of the opposing comb electrodes of the central interdigital transducer comprises: first and second bisected comb electrodes obtained by bisection along the surface-acoustic-wave propagation direction;

the first and second bisected comb electrodes are respectively disposed closer to the first and second interdigital transducers and are respectively connected to first and second balanced signal terminals;

the first and second interdigital transducers which are adjacent to the central interdigital transducer are connected to an unbalanced signal terminal;

the surface acoustic wave filter further comprises: first and second surface acoustic wave resonators respectively connected between the first interdigital transducer and the unbalanced signal terminal and between the second interdigital transducer and the unbalanced signal terminal;

the first and second surface acoustic wave resonators each have an interdigital transducer and reflectors disposed at two sides of the interdigital transducer in the surface-acoustic-wave propagation direction; and

design parameters of the first and second surface acoustic wave resonators differ.

14. The surface acoustic wave filter according to Claim 13, wherein the electrode finger pitch of at least a part of the first surface acoustic wave resonator is greater than the electrode finger pitch of the second surface acoustic wave resonator.

15. The surface acoustic wave filter according to Claim 13 or 14, wherein a ratio between the electrode finger pitch of the interdigital transducer of the first surface acoustic wave resonator and the electrode finger pitch of one reflector of the first surface acoustic wave resonator is greater than a ratio between the electrode finger pitches of the interdigital transducer and one reflector in the second surface acoustic wave

resonator.

16. The surface acoustic wave filter according to one of Claims 13 to 15, wherein an electrode-finger center-to-center distance between the interdigital transducer and one reflector in the first surface acoustic wave resonator is greater than an electrode-finger center-to-center distance between the interdigital transducer and one reflector in the second surface acoustic wave resonator.

17. The surface acoustic wave filter according to one of Claims 13 to 16, wherein the duty of electrode fingers of the second surface acoustic wave resonator is greater than the duty of electrode fingers of the first surface acoustic wave resonator.

18. A surface acoustic wave filter comprising: a piezoelectric substrate; and a longitudinally-coupled-resonator surface acoustic wave filter portion disposed on the piezoelectric substrate,

wherein:

the longitudinally-coupled-resonator surface acoustic wave filter portion comprises: an odd number of at least three interdigital transducers formed so that a plurality of comb electrodes having a plurality of electrode fingers are combined to oppose, the interdigital transducers being disposed along a surface-acoustic-wave propagation direction; and first and second reflectors disposed along the surface-acoustic-wave propagation direction so that the three interdigital transducers are positioned between both reflectors;

the odd number of at least three interdigital transducers comprises: a central interdigital transducer positioned in the center; and first and second interdigital transducers disposed

at two sides of the central interdigital transducer, an electrode finger of the first interdigital transducer which is adjacent to the central interdigital transducer is a ground electrode, and an electrode finger of the second interdigital transducer which is adjacent to the central interdigital transducer is a signal electrode;

one side of the opposing comb electrodes of the central interdigital transducer comprises: first and second bisected comb electrodes obtained by bisection along the surface-acoustic-wave propagation direction;

the first and second bisected comb electrodes are respectively disposed closer to the first and second interdigital transducers and are respectively connected to first and second balanced signal terminals;

the first and second interdigital transducers which are adjacent to the central interdigital transducer are connected to an unbalanced signal terminal;

the surface acoustic wave filter further comprises: first and second surface acoustic wave resonators respectively connected between the first interdigital transducer and the unbalanced signal terminal and between the second interdigital transducer and the unbalanced signal terminal;

the first and second surface acoustic wave resonators each have an interdigital transducer and reflectors disposed at two sides of the interdigital transducer in the surface-acoustic-wave propagation direction; and

design parameters of the first and second surface acoustic wave resonators differ.

19. The surface acoustic wave filter according to Claim 18, wherein the electrode finger pitch of at least a part of the



first surface acoustic wave resonator is greater than the electrode finger pitch of the second surface acoustic wave resonator.

20. The surface acoustic wave filter according to Claim 18 or 19, wherein a ratio between the electrode finger pitches of the interdigital transducer and one reflector in the first surface acoustic wave resonator is greater than a ratio between the electrode finger pitches of the interdigital transducer and one reflector in the second surface acoustic wave resonator.

21. The surface acoustic wave filter according to one of Claims 18 to 20, wherein an electrode-finger center-to-center distance between the interdigital transducer and one reflector in the first surface acoustic wave resonator is greater than an electrode-finger center-to-center distance between the interdigital transducer and one reflector in the second surface acoustic wave resonator.

22. The surface acoustic wave filter according to one of Claims 18 to 21, wherein the duty of electrode fingers of the second surface acoustic wave resonator is greater than the duty of electrode fingers of the first surface acoustic wave resonator.

23. The surface acoustic wave filter according to one of Claims 1 to 22, further comprising a second longitudinally-coupled-resonator surface acoustic wave filter portion cascade-connected to said longitudinally-coupled-resonator surface acoustic wave filter portion.

24. The surface acoustic wave filter according to Claim 23, wherein the second longitudinally-coupled-resonator surface acoustic wave filter portion comprises: a central interdigital transducer; and first and second interdigital transducers

disposed at two sides of the central interdigital transducer, and the number of electrode fingers of the central interdigital transducer is even.

25. The surface acoustic wave filter according to Claim 23 or 24, further comprising:

a first signal line for electrically connecting the first interdigital transducer of the second longitudinally-coupled-resonator surface acoustic wave filter portion and the first or second interdigital transducer of said longitudinally-coupled-resonator surface acoustic wave filter portion; and

a second signal line for electrically connecting the second interdigital transducer of the second longitudinally-coupled-resonator surface acoustic wave filter portion and the second or first interdigital transducer of said longitudinally-coupled-resonator surface acoustic wave filter portion,

wherein the phases of signals transmitted through the first and second signal lines have a difference of approximately 180 degrees.

26. A communication apparatus including the surface acoustic wave filter as defined in one of Claims 1 to 25.